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COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Improvements in or relating to the Manufacture of Synthetic Aggregates

I, JOHN WILLIAM RICHARD WRIGHT, of Woodlands, Giles Lane, Canterbury, in the County of Kent, a British Subject, do hereby declare the invention, for which I pray that a Patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the manufacture of synthetic aggregates.

Aggregates are used for various purposes in the building trade. For example, for concrete in the construction of prefabricated units, and in the construction of roads and paths. The supply of natural aggregates has a tendency not to keep up with the demand, with the result that important work may be delayed due to late delivery of the aggregates and a further disadvantage is that the cost of natural aggregates has risen to the excess of demand over supply.

Certain waste materials today for which there is no present use have to be disposed of, such as the ash from furnaces, particularly pulverised fuel ash (frequently called "p.f.a.") from larger boiler installations and electric generating stations, and the cost of disposal of p.f.a. is substantial. Coal mines, slate quarries and other workings also have the problem of the disposal of waste matter after the useful material has been separated from the quarried material.

One of the objects of the present invention is to overcome some or all of the above difficulties.

According to the present invention there is provided the process for the continuous production of aggregates from clay or material containing clay and using pulverised fuel ash, finely divided slag, shale or any mixture of such materials which includes the steps of mixing the said material with water to the required consistency with the addition of clay where necessary so that when divided into granules the granules will not readily adhere to one another or break up, dividing the mix into granules of the desired size and shape by extruding the mix and cutting the extruded material into lengths, feeding said granules to a kiln in which the atmosphere is dry and at a temperature of 150°-200°C., progressing said granules through said kiln in the presence of a gaseous oxidising agent, sintering said granules, and discharging said granules from said kiln.

When using slag it should be finely divided and the finely divided slag may be produced by dry grinding. Some slags or shales disintegrate into suitable fineness by weathering and large quantities are available in some districts. Generally speaking, all the powdered slag and shale which will pass through approximately 80 mesh sieve (British Standard Sieve) is suitable for producing aggregates. With such a grading a very large proportion would be very fine powder and that approaching the 80 mesh size would give a variation in the powder, which is beneficial. The quantity of water used in the mix and the proportion of clay to fine material are both regulated according to the nature of the final product desired. The higher the proportion of water the less will be the specific gravity of the granules. Obviously the less clay that is used the cheaper will be the product, but sufficient clay has to be used to secure a satisfactory bond and sintering and the percentage of clay is preferably not less by volume than 5% for slag and 2.5% for pulverised fuel ash. Here it must be appreciated that the water content of all clays varies considerably, and in determining the amount of additional water to be used this

variation has to be taken into consideration. The water content of the mix may be between 20% and 30% by volume.

According to the present invention there is provided apparatus for carrying out either of the two above mentioned processes which includes a cylinder having extrusion apertures on its surface, a roller mounted eccentrically within said cylinder but in spaced relation thereto so that clay or clay mixture fed into said cylinder is compacted in a layer on its inner surface which layer is added to at every successive rotation whilst part of said layer is extruded through said apertures. Means may be provided for adjusting the roller for varying the thickness of the layer until contact with the cylinder causes automatic discharging. Means may also be provided for controlling the supply of raw materials and both means may be operable whilst the plant is in operation.

Said apparatus includes a receiver for the ingregients of the mix, including water, mixing means, a conveyor for said mix to extrusion means, extrusion means for receiving said mix, cutting off means for dividing the extruded material into granules, a sintering kiln for receiving said granules and means for progressing said granules through said kiln and discharging them therefrom when sintered. Said apparatus may comprise measuring means for determining the quantity of water in relation to a particular weight of mix. Mixing means may also constitute the conveying means and take the form of a pug mill. The extrusion means may constitute a mill consisting of a drum into which the mix is fed and in which there is eccentrically disposed a freely-rotatable adjustably mounted roller so that as the drum is rotated the mix is squeezed between the roller and the wall of the drum, the said drum being pierced on its periphery to permit the contents thereof to be extruded. Adjustable cutting means may be provided adjacent the periphery of the drum, so that as the material is extruded through the apertures in the drum it is automatically cut off by the cutting means into granules of approximately the desired size. The position of the cutting means may be adjustable, thereby regulating the size of the granules formed by cutting off the extruded material. The drum may have apertures of all the same size or of different sizes, or may be provided with a detachable apertured portion so as to enable the size to be selected by interchanging the extrusion plate. The kiln may be of substantially cylindrical form, mounted for rotation about its axis, and the floor of the kiln may be inclined in order to provide for automatic progression of the granules through the kiln. The inlet end of the kiln may be slightly conical, thereby providing a slope and avoiding the necessity of inclining the axis of the kiln, such inclination may be within the limits of 2° and 15° and preferably about 5°. If the inlet end is conical the passage of the material along the conical surface will obviously be speeded up and this can be used for material that needs less drying time.

In order to control the speed at which the granules are discharged from the kiln, and delay their discharge somewhat, at the sintering end of the kiln a weir or annular ridge may be provided in the kiln over which the granules have to pass before leaving the kiln. Said weir or annular ridge may be sharply declined on the discharge side for the quick discharge after sintering of certain aggregates particularly those made from pulverised fuel ash. The feeding means at the inlet end of the kiln may comprise a receptacle for the extruded granules which is valved or shuttered by the inlet end of the kiln, which, for this purpose and in order to provide an even distribution at the end, may be provided with radial fins or axially and peripherally arranged tubes. In order to provide some control of the passage of hot gases through the kiln, other than by the control of the flame injector at the outlet end, an exhaust fan may be provided at the inlet end for drawing the hot gases through the kiln, said exhaust fan having a variable control, either by way of speed or by adjustable nozzle.

The process may be considered as being in two stages or sections, though of course in practice it is a continuous operation. The first of these deals with raw materials. In the second the aggregates of raw materials, made in the first stage, are sintered or heat treated, according to the nature of the raw materials used, in a vertical or horizontal rotating kiln or chamber in which the heated air or gases, which are circulated or passed through the kiln or chamber, are carefully regulated either at the fuel end of the kiln or chamber, or by means of an exhauster fan with calibrated discharge orifices, placed at the raw material feed end of the kiln or chamber.

In order that the invention may be more clearly understood, one method and one apparatus for the manufacture of synthetic granules from boiler ash will now be described in detail.

Referring to the drawings accompanying the Provisional Specification;

Fig. 1 is a diagrammatic longitudinal elevation of one form of apparatus for carrying out the method in accordance with the present invention;

Fig. 2 is a fragmentary plan view of the water feed and emulsion hopper;

Fig. 3 is a plan view, partly in section, of the kiln shown in Fig. 1;

Fig. 4 is a front elevation and

Fig. 5 is an elevation of the extrusion mill shown in Fig. 1;

Fig. 6 is a diagrammatic elevation of the metering device shown in Fig. 1.

Figs. 7 and 8 are diagrammatic side and front elevations of a gas burner for the kiln shown in Fig. 1.

Figs. 9 and 10 are part sectional diagrammatic side and front elevations of a modified form of gas burner.

Referring to the accompanying drawings:

Fig. 11 is a part sectional elevation of a modified form of apparatus made in accordance with the present invention,

Fig. 12 is a perspective view partly broken away of the mill cutter and conveyor embodied in Fig. 11,

Fig. 13 is a plan view of the emulsifier and the kiln supporting frame shown in Fig. 11.

Fig. 14 is a perspective view partly broken away showing the kiln at the mill end.

Fig. 15 is a side elevation partly in section of the feed to the emulsifying hopper and the metering valve at the base.

In all the forms shown in the drawings the apparatus comprises a lift or elevator 2 for raising and discharging clay into the clay emulsifier 4 in which the clay is foamed or emulsified with water and discharged into the emulsion hopper 6, where it is kept stirred by paddles 8 which stir and agitate the mixture of clay and water into foam or emulsion. At this stage any fluxes required for sintering and/or foaming agent are added. Water is metered into the emulsifier 4 by means not shown. The quantity of water fed into the emulsifier determines the moisture content of the mix and is fairly critical. The exact amount of water required is usually determined in the laboratory but the correctness of the mix in this respect is easily checked under working conditions by hand testing.

At this stage in the process any materials which may assist emulsifying or foaming of the clay and water, or the sintering of the mixed materials, the plastic mixture, in the second stage of the process or to inhibit adhesion after extension, may be added. Arranged alongside the clay emulsifier 4 and emulsion hopper 6 is an ash hopper 10. The emulsion hopper 6 and ash hopper 10 have discharge orifices controlled by metering valves 12 and 14 through which the contents are discharged into the pug mill 16 constituting a mixing conveyor. The valves 12 and 14 each comprise a rotating measuring disc 20 (Fig. 6) having peripheral recesses 22 by which the contents of both hoppers are individually and simultaneously metered into the inlet hood 24 of the mixer conveyor 16 in which the foamed or emulsified clay and the ash are thoroughly mixed. As will be seen, the mixer conveyor 16 is inclined from the vertical and its upper end 28 discharges the mix in a plastic form into the granulating mill.

As will be seen from Fig. 4, the granulating mill consists of a drum 30 mounted for rotation on its axis which drum 30 is perforated at intervals with apertures 32 through which the contents of the mill are adapted to be extruded. Disposed eccentrically within the drum 30 in spaced relation thereto which may be made adjustable is a roller 34 mounted free to rotate on its axis. The mixer conveyor 16 discharges into the gap 38 between the roller 34 and the drum 30 at the point *a* (Fig. 4) which is about level with the horizontal centre line through the axis of the roller 34, and as the drum 30 rotates the mix is trapped in the narrowing space between the points marked *a* and *e* and squeezed so that the mix forms a solid wall of compacted mix against the inner wall of the drum which is added to continuously as the drum rotates, causing part of the wall to be extruded through the apertures 32. This action of sequentially compacting the mixture against an extrusion surface constitutes a continuous and combined de-aerating process and extrusion process going on simultaneously.

The action of the granulating mill, or grading mill as it may be termed, is to subject each part of the mix to repeated pressure prior to extrusion, the effect of which is to remove much of the air from the mix. The ratio of the area of the apertures 32 to the total area of the drum 30 controls the amount of pressure to which the clay is subjected as it is squeezed and is one of the factors which determines the degree of de-aerating effected, another factor being the size of the gap 38.

Adjustment of the roller 34 is provided as hereinafter described in order to enable the gap to be varied and even eliminated. The degree of de-aerating can be controlled by the rate of feed, the ratio of the apertures to the total area and the size of the gap 38 between the drum 30 and the roller 34.

Positioned adjacent the periphery of the drum 30 is a fixed cutter 40 which is mounted for adjustment around the drum 30 so that it can be moved within limits around the drum 30, thereby determining the length of the material extruded from the apertures before being cut off into granules. Instead of a fixed cutter blade 40, which merely cuts off lengths of extruded material, fixed wires may be used or a high speed rotary cutter may be provided having knives suitably arranged so that

they cut the extruded material into shreds of the desired size according to the spacing of the knives and their angle of presentation to the extruded material.

These granules, on falling, collect in an inlet hood 50 disposed at the inlet end 52 of a horizontally mounted rotary kiln 54 having peripheral supporting bands 56 carried on four rollers 58, two on each side of the kiln 54. A motor 64 drives through a reduction gear 66 to the shafts 68 and 70, each of which carries one of the rollers 58. Chains 72 and 74 drive short layshafts 76 and 78 each carrying a roller 58 located on the other side of the kiln 54. All shafts are journalled in bearings on the frame 80 on which the motor 64 is also mounted. In this way the kiln 54 is rotated on its axis when the motor 64 is running.

The inlet end of the kiln 52 which faces the inlet hood 50 co-operates therewith as a shutter to control the admission of granules to the kiln 54. Through the said inlet a certain controlled amount of air may be permitted to be drawn to control the temperature of the hot gases passed through the exhauster fan. This is so in the case of material requiring a fairly high sintering temperature. The absence or shortage of moisture in these raw materials might permit of hotter gases passing through the kiln than was desirable. The exhauster fan is designed for hot gases at temperatures normally used in the process. The air inlet is a safety measure. This is not a critical feature but a somewhat important point in practice.

As will be seen from Fig. 1, the inlet end 52 of the kiln 54 is slightly tapered for about two thirds of its length so as to provide a gentle downward slope of the floor towards the final third of its length which is cylindrical. Near the inlet hood 50 the kiln 54 is also provided with radial vanes 82, the purpose of which, in co-operation with the inlet hood 50, is to distribute the incoming granules evenly in the kiln and to assist in their dispersal for drying. An alternative construction embodying oval tubes is described in relation to Fig. 14. Also mounted at the inlet end of the kiln 54 is an exhauster fan 84 and at the outlet end is the burner nozzle 86 of an gas burner mounted for pivotal movement in any direction so that the flame can be directed at the desired angle on to the granules.

As the kiln 54 rotates the granules move slowly along the kiln down the inclined floor from the inlet to the outlet. It is preferred to use a burner having a comparatively short flame and to provide the burner with a nozzle or nozzles shaped to direct the hot gases on to the layer of granules travelling along the bottom of the cylinder as they tumble over and over towards the outlet.

It will be seen that at the outlet end the kiln 54 is provided with an internal peripheral annular ridge 88 which forms a weir where the granules collect before passing out of the kiln into a hopper or onto a conveyor (not shown). In order that the kiln 54 may be made mobile, the frame 80 may be provided with lugs 90 for the attachment of a mobile chassis (not shown). These lugs 90 are also made to serve as supports for the kiln when in use and the tilt of the axis of the kiln can be adjusted to suit requirements by the application of suitable packing or the provision of jacking means beneath said frame. During the first third of such movement the granules are dried. In the second third the carbonaceous matter when present is oxidised and in the last third the granules are sintered.

A procedure similar to that for ash described above may be used with powdered shale or slag which in certain districts is available in large quantities. With clays and other shales the raw clay or shale is supplied into the mixer-conveyor 16, where the moisture content may also be adjusted as required by added water. This is not a critical process as with plasticised ash, etc.

Reference will now be made to Figs. 7 and 8, in which are shown a gas burner of a kind which has been successfully used in the kiln illustrated in Fig. 1 in substitution for the oil burner. The gas and air are mixed in the chamber 100 having a circular end wall 102 provided with a semi-circular slot 104 from which the combustible mixture issues and burns in a short flame. This is downwardly directed towards the granules tumbling over and over as the kiln 54 is rotated, causing the granules to move slowly towards the ridge 88 before passing out of the kiln. It will be noted that the burner is offset slightly in the direction of rotation. This burner is suitable for general purpose use.

In the form of burner shown in Figs. 9 and 10 of the drawings accompanying the provisional specification the funnel-shaped mixing chamber 100 is replaced by a tube 106 provided with a plurality of sloping slots 108 from which the combustible mixture of gas and air escapes and burns in short downwardly directed flames. Again it will be seen that the burner is slightly offset to bring the greatest heat where the aggregate is deepest. This burner would be more suitable for slag and ash mixture, but might be too fierce for clays and some shales. In Fig. 11 of the drawings accompanying the complete specification and described hereafter a modified form of gas burner 86 is shown, the construction of which is clearly illustrated.

If it is desired to use the above appara-

tus for the production of artificial aggregates from clay alone, all that is necessary is to feed the raw clay into the mixer conveyor 16. Obviously in both cases if the clay as quarried contains stones it will be necessary to subject the clay to a preliminary process for the purpose of removing such stones which could otherwise damage the granulating mill.

It has been found that the de-aerating affects the final density of the granules and the density is not really affected by the amount of water because as the water is evaporated the clay contracts and compacts. The de-aerating process is also important for controlling the firing of the granules. Some clays, particularly "Oxford clay," contain carbon in the form of shale oil and furnace ash also contains some carbon. If the amount of air in the clay or clay mix is not controlled the aggregates may be burnt to clinker instead of being sintered in the sintering zone of the kiln.

Another important feature of the invention consists in arranging for a rapid drying of the green or freshly extruded granules at the inlet end 52 of the kiln 54, so as to dry the skin and reduce any tendency for the green aggregates to stick together or break up, continuing the drying process until dehydration is complete, which stage in the example given takes place during the tumbling of the granules down the tapered first two-thirds of the length of the kiln and controlling the rate of passage through the sintering zone of final third of the length of the kiln. The rate of passage through both zones is controllable by adjusting the tilt of the axis on which the kiln 54 rotates and the final movement out of the kiln can be controlled by the peripheral ridge 88 at the outlet and/or by varying the speed of rotation.

Referring now to the drawings accompanying the complete specification it will be seen from Fig. 11 that the apparatus has only been modified in details. Instead of the radial vanes referred to in the Provisional Specification the inside of the kiln 54 at the inlet end 52 is provided with a number of oval tubes 120 (Fig. 14) arranged around the periphery, evenly spaced and in contact with each other.

In the example illustrated eight tubes are shown in the seven foot diameter kiln. For larger kilns more tubes would be used. These each form a separate drying chamber and the oval shape avoids the presence of any corners in which the extruded wet aggregates might accumulate. At the inlet end the central space 122 between the tubes 120 is blanked off with a plate 124 in which are provided a number of small vent holes 126, one radially adjacent to each tube. The purpose of these ventilation holes 126 is to prevent the formation of a pocket where stagnant gases might accumulate, resulting in condensation when starting the plant and other troubles.

In Fig. 12 at the drawings accompanying the complete specification the mill illustrated in Figs. 1 and 11 at the drawings accompanying the provisional specification is shown in greater detail. The roller 34 is carried on an eccentric sleeve 110 carried on a fixed pin 112, screwed at the end to receive a locking lever 113. Integral with the sleeve 110 is a lever 114 by which the sleeve can be turned on the pin so as to vary the gap 38 and even close it completely so as to be able to empty the drum 30 when required. In practice a plant such as this, if used for converting the ash from a steam raising plant, would be started up simultaneously with the steam raising plant so that the ash as it is produced is continuously passed to the plant and converted into aggregates. When the plant is shut down the lever 114 is adjusted to bring the roller 34 into contact with the drum 30 and so automatically empty the drum 30 in preparation for restarting. Any material left in the holes is pushed out as soon as the new charge enters the mill and extrusion commences.

Instead of a fixed cutter 40 (Fig. 4) there are shown a number of wire cutters 121 carried on a frame 123 mounted on a pivot 125 carried in a bracket 127 mounted on the frame of the mill. A balance weight 146 is provided which is carried on an arm 129 secured to the frame 123 and urges the wires 121 towards the drum 30. Four are shown, but any convenient number may be used and are arranged on the arc of a circle conforming to the periphery of the drum 30.

As will be seen from this Fig. 12, there is provided a device for feeding sand for coating the aggregates before they enter the kiln. A hopper 130 for sand fitted with a fixed blade 132 mounted in the centre of the mouth of the hopper has its bottom edge positioned close to a plate 134 mounted for reciprocation by means not shown conveniently driven from the mill drive. As the sand is pushed off the ends of the plate 134 by the reciprocation motion, it falls on to a conveyor belt 136 which passes beneath the mill 30 from which the aggregates are being extruded, so that the granules fall on to the sanded belt and the sand and granules are conveyed and discharged into the inlet hood 50 of the kiln 54. Any convenient number of extrusion mills 30 may be provided and arranged to discharge on to the belt 136 and each mill may produce different or the same size granules.

Turning now to Fig. 13 of the drawings

accompanying the complete specification. It will be seen that in addition to the fixed scrapers 140 shown within the emulsifier, there are provided a number of blades 142 which are curved to present a convex face to the mix as it rotates. These blades 142 are set with their outer edges a short distance from the inner periphery of the rotating drum of the emulsifier 4 whilst the scrapers 140 are set to scrape the revolving drum almost clean. The convex surfaces were found more effective than a flat or concave blade in keeping the mix moving and breaking it up.

Fig. 15 shows in greater detail a diagrammatic view of the valve seen in Fig. 6 which is fitted at the base of the hoppers for the emulsion and ash. The metering valve consists of a notched drum 150, the notches each having a predetermined volume so that each will deliver a known quantity whether of ash or emulsion. The only difference between the two valves is that the one for the emulsion is provided with a sealing leather sheet 152 fixed to the mouth of the hopper 154. This sheet is not necessary for the ash valve for which a small air gap suffices. The revolving drum is mounted on a lever 156 pivoted at 158 and carrying an arm 160 for a balance weight 162 to keep the drum in contact with the leather sheet. For the ash valve to stop (not shown) is provided to determine the size of the air gap. The emulsifier 4 feeds into the emulsifier hopper 6 through a pipe 172 (Fig. 15) controlled by a valve 174.

The apparatus above described for the continuous production of synthetic aggregates from the pulverised fuel ash, being about 15% of the total fuel used, enables the ash to be converted where made at an economical cost into high grade light-weight aggregate 32 to 40 lbs. per cubic foot. Otherwise the ash is costly to transport and dispose of. The aggregate thus produced from pulverised fuel ash, a waste material, is suitable for general building purposes:—foundations, bricks, or pre-cast sections, floors, tiles and the like.

Such a plant of a sufficient capacity to absorb all the pulverised fuel ash being made may be started simultaneously with the steam raising plant and stopped immediately ash production ceases when shutting down the steam raising plant. All the pulverised fuel ash resulting from large steam raising plant is thus immediately converted from a waste material, costly to dispose of, into a valuable high grade light-weight aggregate. The light weight of these aggregates reduces the cost of transport and handling as compared with other aggregates, as well as reducing the amount of steel required in the actual building where the concrete is used. The extreme lightness of pulverised fuel ash enables aggregates to be produced having a weight of between 32 and 38 lbs. per cubic foot as against 120 lbs. per cubic foot of stone aggregate.

The aggregates made under the conditions described above may be dumped, while hot as sintered, in the open exposed to all weathers, when a natural hardening process or action similar in effect to that known geologically as "concretion," which weathering fosters, takes place. This natural process or action develops where cementitious materials, such as silica or alumina, are present, as is the case with pulverised fuel ash and clay.

The before described apparatus or plant for making synthetic aggragates may be in suitable mobile form for moving to sources of various raw materials.

The conical or tapered kiln above described is intended mainly for handling plastic ash and powdered slag mixtures which may be passed more quickly through the process than plastic clays and shales for which a parallel kiln is permissible. The conical kiln may be used for clays, etc., by adjusting the slope of the kiln to check or control the speed of the clay ,etc., aggregates through the kiln.

A similar procedure to ash may be used with powdered slag or shale, which in certain districts is available in large quantities.

With clays and shales which can be made plastic the metering and emulsifying apparauts is not required. The clays or shales are put into the mixer conveyor which in this case acts as a regulator to ensure a regular and steady feed of clay or plastic shale into the mill for compounding and de-airing as in the case of the plastic mixtures already described. The moisture content of the clay or plastic shale, which is not so critical as with the plasticised ash, etc., may be adjusted as required with added water in the mixer conveyor.

With the apparatus described above it will be observed that in the second or sintering stage the green aggregates are passed into the feed end of a rotating kiln or chamber. The heated air or gases, which are circulated or passed through the kiln or chamber, are carefully regulated either at the fuel feed end of the kiln or chamber, or by means of an exhauster fan with calibrated discharge orifices placed at the raw materials or green aggregates feed end of the kiln or chamber. The atmosphere into which the green aggregates are passed in the kiln or chamber must, as already indicated, be dry and at a temperature of 150° to 200°C, which will rapidly dry the outside or skin of the green aggregates to prevent them sticking together or breaking up and this temperature is main-

tained within certain limits, to enable dehydration of the green aggregates to be attained before any sintering takes place. In drying, slight shrinkage of the aggregates (except with hard slag or shale) may occur, but this does not affect the density of the aggregates which is regulated in the compounding and de-airing stage. In sintering partial vitrification of the aggregates takes place, but this is regulated according to the nature of the raw materials used and the kind of finished aggregates required. In the sintering section or zone of the kiln or chamber the heat is applied to the lower portion of the kiln and directed mostly on to the aggregates which are being sintered and not on to the lining (refractory material) of the kiln, which therefore remains comparatively cool. With a comparatively short sintering zone and the rotating of the comparatively cool lining of the kiln, very effective control of the sintering or vitrification of the aggregates within narrow limits is possible. This control is essential, especially with minerals with what is termed a narrow "vitrification range," which means that the material will quickly fuse. The sintering of the green aggregates is controlled by:— Regulating the amount of heat supplied by the oil burner or other form of heat supply (suction gas or the like) in the kiln. Regulating the amount of green aggregate fed into the kiln, according to the nature of the raw materials used and their reaction to heating. Controlling the composition of the hot gases in the kiln by means of the exhauster fan and the fuel (oil or gas) supply. Varying the speed of rotation of the kiln to retain a larger or smaller volume of sintering aggregates in contact with the heat. Varying the angle of incline of the kiln.

All the above-mentioned features are provided for dealing with a wide range of raw materials, some of which are available in most areas. Provision is also made for regulating the discharge from the kiln in the form of a weir shaped in the kiln lining.

WHAT I CLAIM IS:—

1. The process for the continuous production of aggregates from clay or material containing clay and using pulverised fuel ash, finely divided slag, shale or any mixture of such materials which includes the steps of mixing the said material with water to the required consistency with additional clay where necessary so that when divided into granules the granules will not readily adhere to one another or break up, dividing the mix into granules of the desired size and shape by extruding the mix and cutting the extruded material into lengths, feeding said granules to a kiln in which the atmosphere is dry and at a temperature of 150-200°C, progressing said granules through said kiln in the presence of a gaseous oxidizing agent, sintering said granules, and discharging said granules from said kiln.

2. The process according to claim 1 which includes the step of using clay bearing shale alone or mixed with other ingredients in order to obtain the desired plasticity.

3. The process according to claim 1 or 2 wherein sand is added to the granules before being fed to the kiln.

4. The process according to any one of the preceding claims wherein fluxes and or a foaming agent is added to the mix before the extrusion.

5. The process according to any one of the preceding claims 2 to 4 wherein the proportion of normal consistency clay to fine material is not less bv volume than 5% for slag and 2.5% for pulverised fuel ash.

6. The process of producing aggregates according to any one of the preceding claims which includes a de-aerating step of sequentially compacting the mixture against an extrusion surface in successive layers the compacting of a succeeding layer causing extrusion from a preceding layer simultaneously with de-aeration of the remaining mass.

7. The process according to any one of the preceding claims wherein the material is first passed through an 80 mesh sieve.

8. Apparatus for the continuous production of aggregates by the process claimed in any one of the preceding claims which includes a receiver for the ingredients of the mix including water, mixing means, a conveyor for said mix, extrusion means receiving said mix, cutting off means for dividing the extruded material into granules, a sintering kiln for receiving said granules and means for progressing said granules through said kiln and discharging them therefrom when sintered.

9. Apparatus according to claim 8 wherein measuring means are provided for measuring the water for the mix.

10. Apparatus according to claim 8 or 9, wherein the mixing means also constitutes conveying means.

11. Apparatus according to any one of the preceding claims 8 to 10, wherein the extrusion means rotates in relation to fixed cutting-off means.

12. Apparatus according to any one of the preceding claims 8 to 11, wherein the kiln is circular in cross section and rotatable and is provided with inclined walls for progressing said granules through said kiln the angle of inclination of the axis of the kiln being within the limits of 2° nad 15° and preferably 5°.

13. Apparatus according to claim 12, wherein said kiln is conical at the inlet.

14. Apparatus according to claim 13 or 14 wherein said kiln is provided internally at the outlet with an inwardly projecting retaining ridge constituting a weir lower than the

inlet to delay discharge of granules and control their progression.

15. Apparatus according to any one of the preceding claims 12 to 14 wherein the kiln is divided at the inlet end by radial vanes.

16. Apparatus according to any of the preceding claims 8 to 15 wherein said kiln is divided for the first part of ts length into a number of peripherally arranged tubular chambers.

17. Apparatus according to any one of the preceding claims 8 to 16, wherein means are provided for controlling the speed of hot gasses through the kiln.

18. Apparatus according to any one of the preceding claims 8 to 17 wherein means are provided for controlling the slope of the kiln.

19. Apparatus according to any of the preceding claims 8 to 17 wherein means are provided for controlling the rate of feed to the kiln and flow of gasses through the kiln.

20. Apparatus according to any of the preceding claims 8 to 19 wherein means are provided for emptying the extrusion means.

21. Apparatus according to any of the preceding claims 8 to 20 for carrying out the process according to claim 7 wherein said extrusion means consists of a roller mounted within a perforated cylinder.

22. Apparatus according to claim 21 wherein said roller is adjustably mounted relatively to said cylinder.

23. Apparatus for carrying out the process claimed in claim 7 which includes a cylinder having extrusion apertures on its surface a roller mounted within and eccentrically of said cylinder but in spaced relation thereto so that clay or clay mixture fed into said cylinder is compacted in a layer on its inner surface which layer is added to at every successive rotation whilst part of said layer is extruded through said apertures.

24. The process of making aggregates substantially as herein described with reference to the drawings.

25. Apparatus for making aggregates constructed and arranged substantially as herein described with reference to and as illustrated in Figs. 1 to 10 of the drawings accompanying the provisional specification as amplified by the description of the additional details of the same plant illustrated in the accompanying drawings.

26. Apparatus for making aggregates constructed and arranged substantially as herein described with reference to and as illustrated in the drawing filed with the provisional specification amplified by the additional detail drawings filed herewith as modified in accordance with Fig. 11 of the accompanying drawings.

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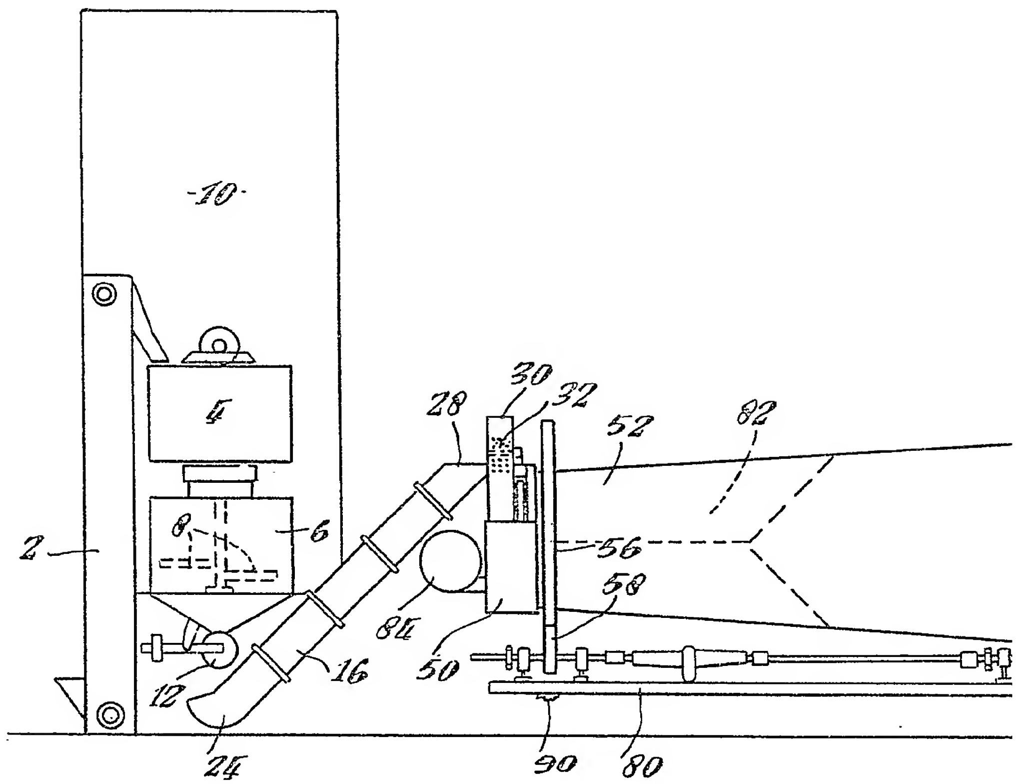
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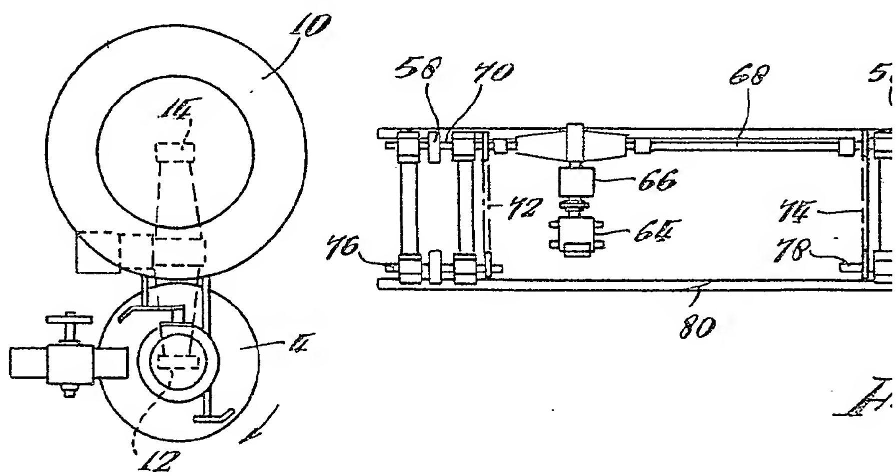
Fig. 2.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972,851 PROVISIONAL SPECIFICATION

2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEET 1

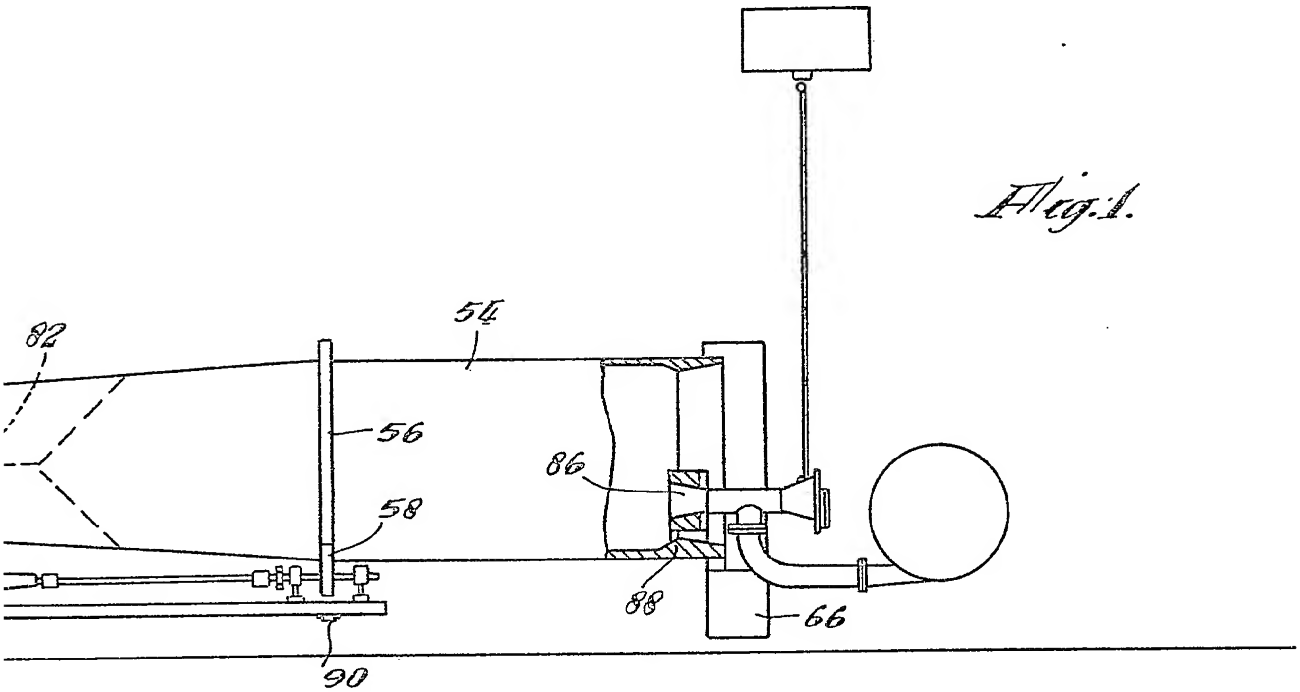

Fig. 1.

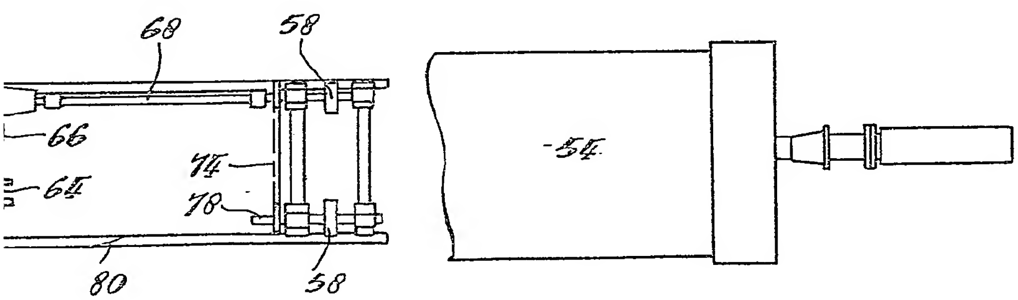

Fig. 3.

972,851 2 SHEETS

PROVISIONAL SPECIFICATION

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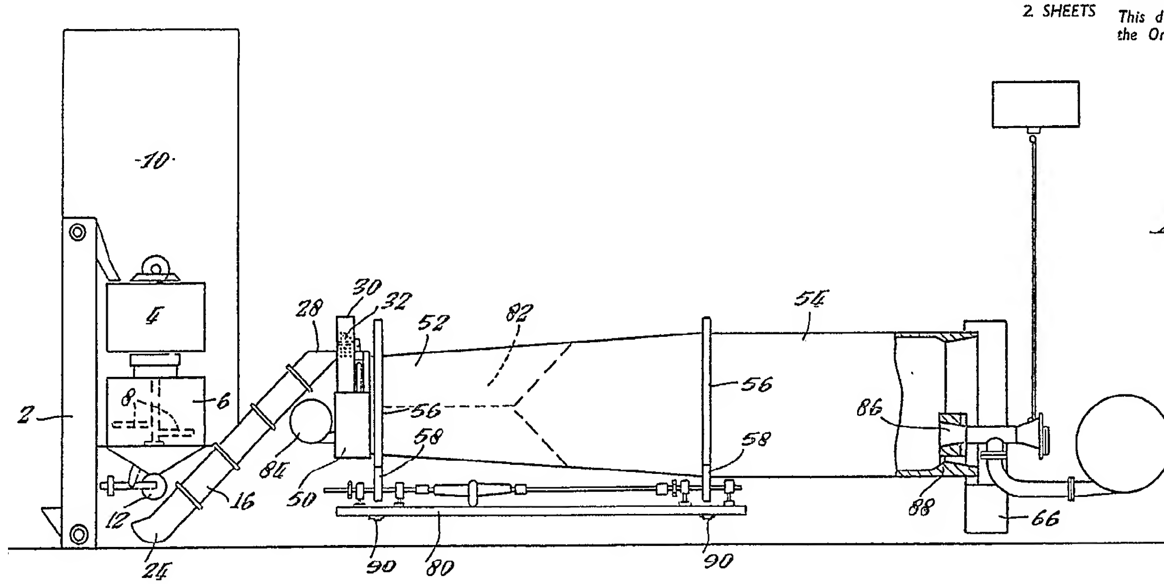
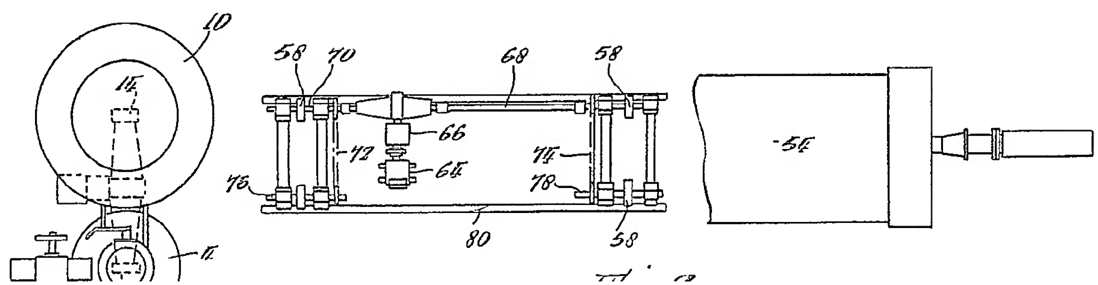


Fig.1.

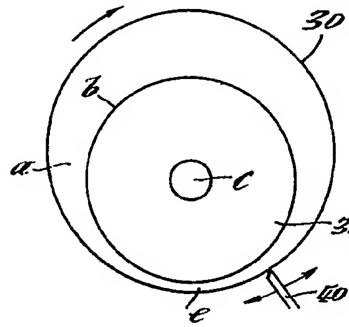
Fig.2.



972,851 PROVISIONAL SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*

SHEET 2



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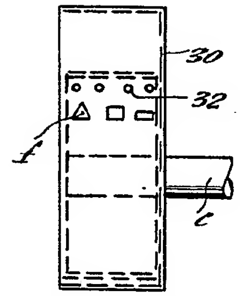

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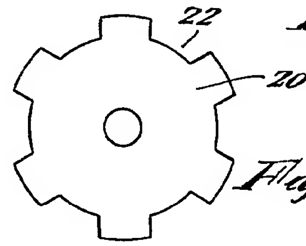

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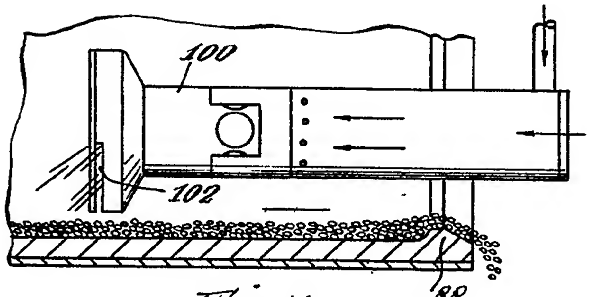

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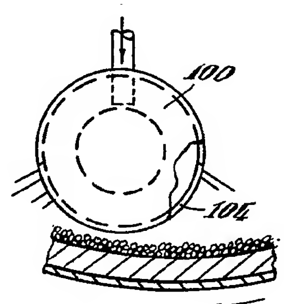


Fig.8.

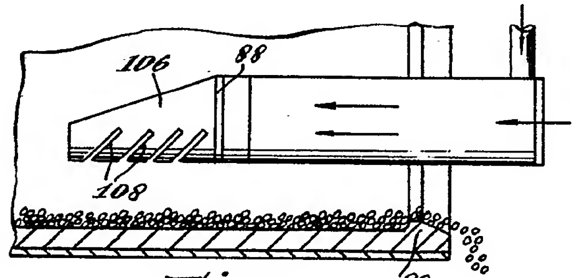
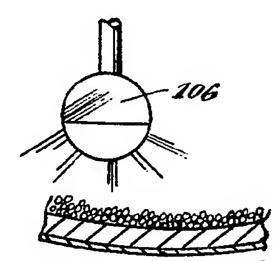


Fig.9.



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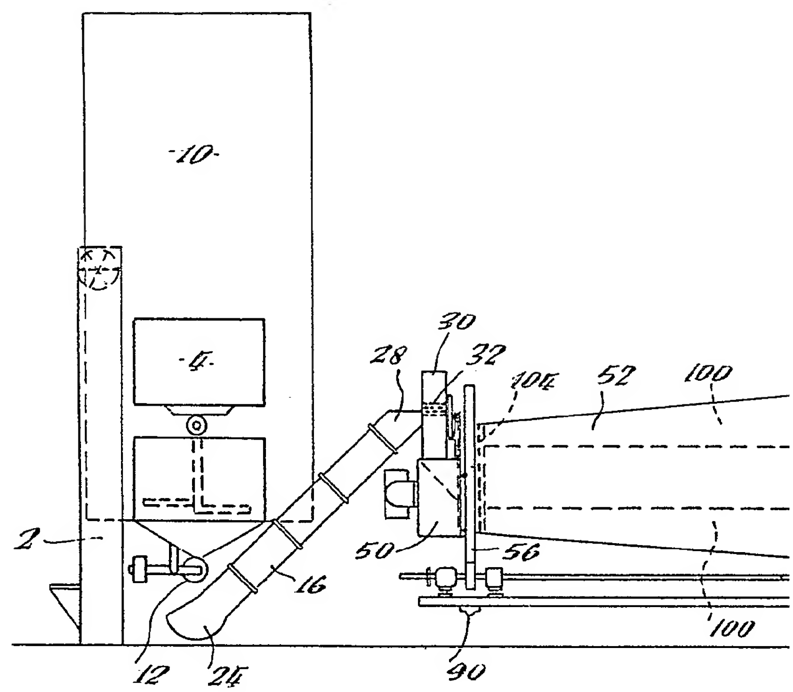

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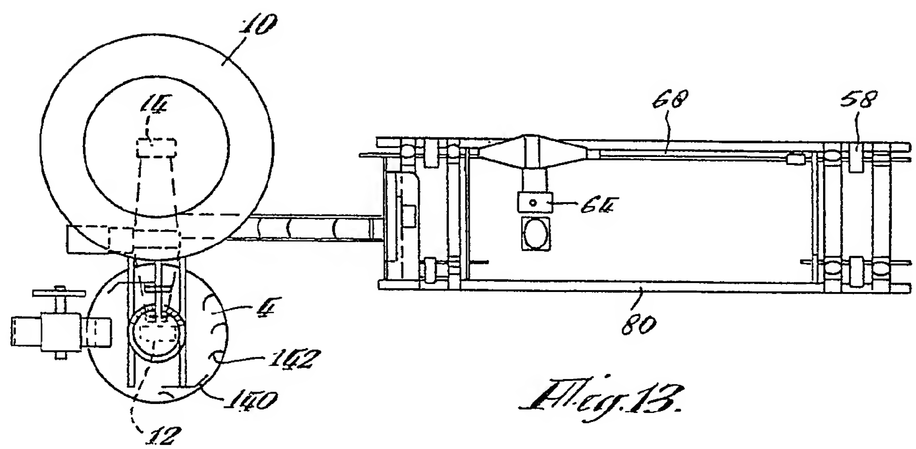

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Fig.13.

972,851 COMPLETE SPECIFICATION
2 SHEETS
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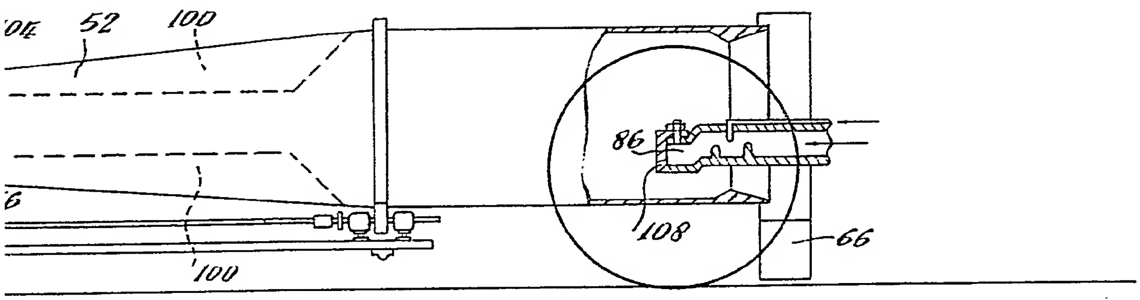

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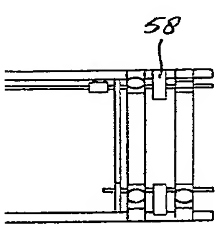

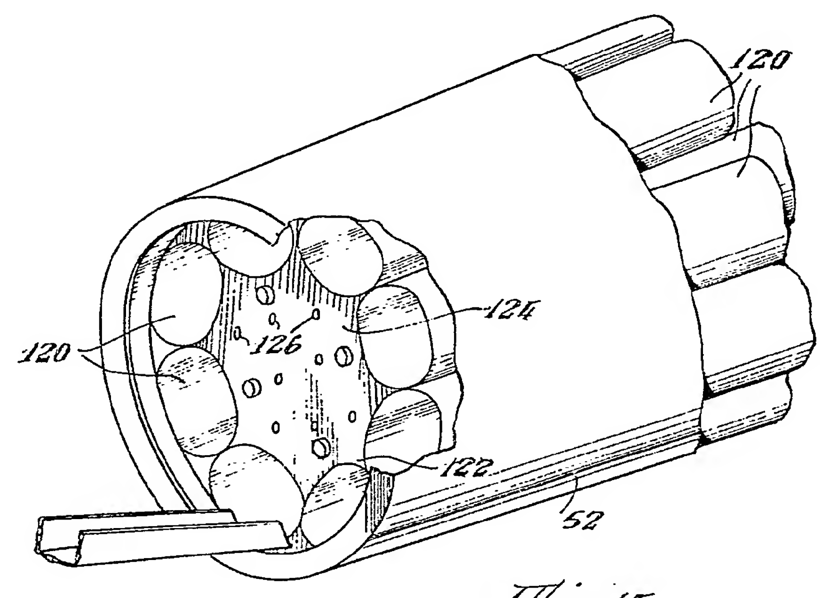

Fig. 14.

972,851 COMPLETE SPECIFICATION
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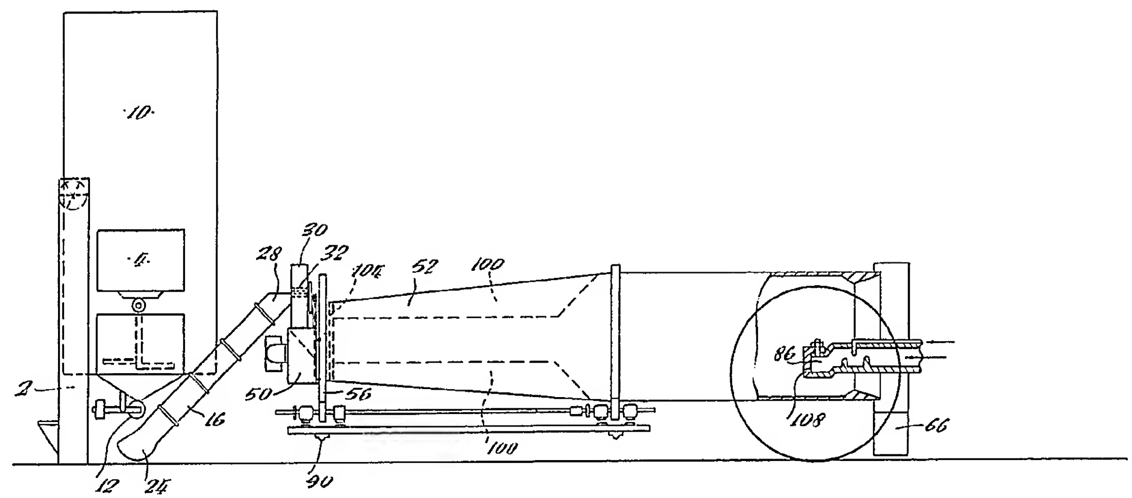

Fig.11.

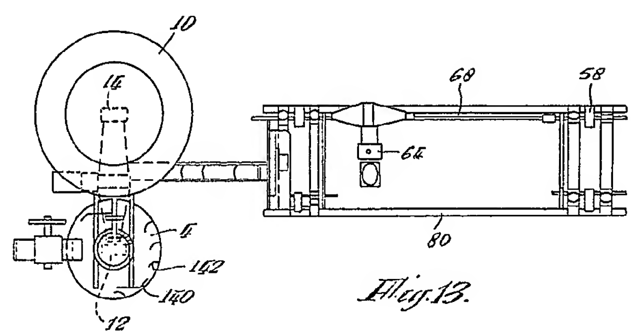

Fig.13.

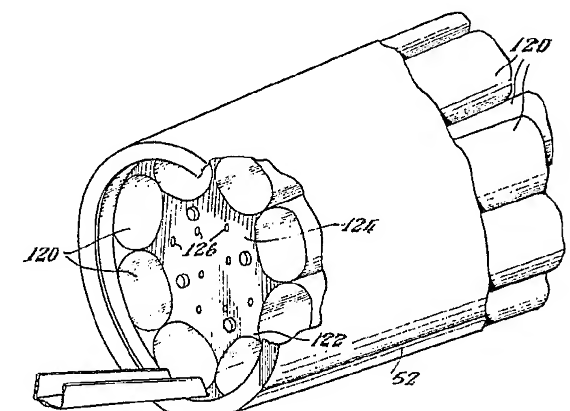

Fig.14.

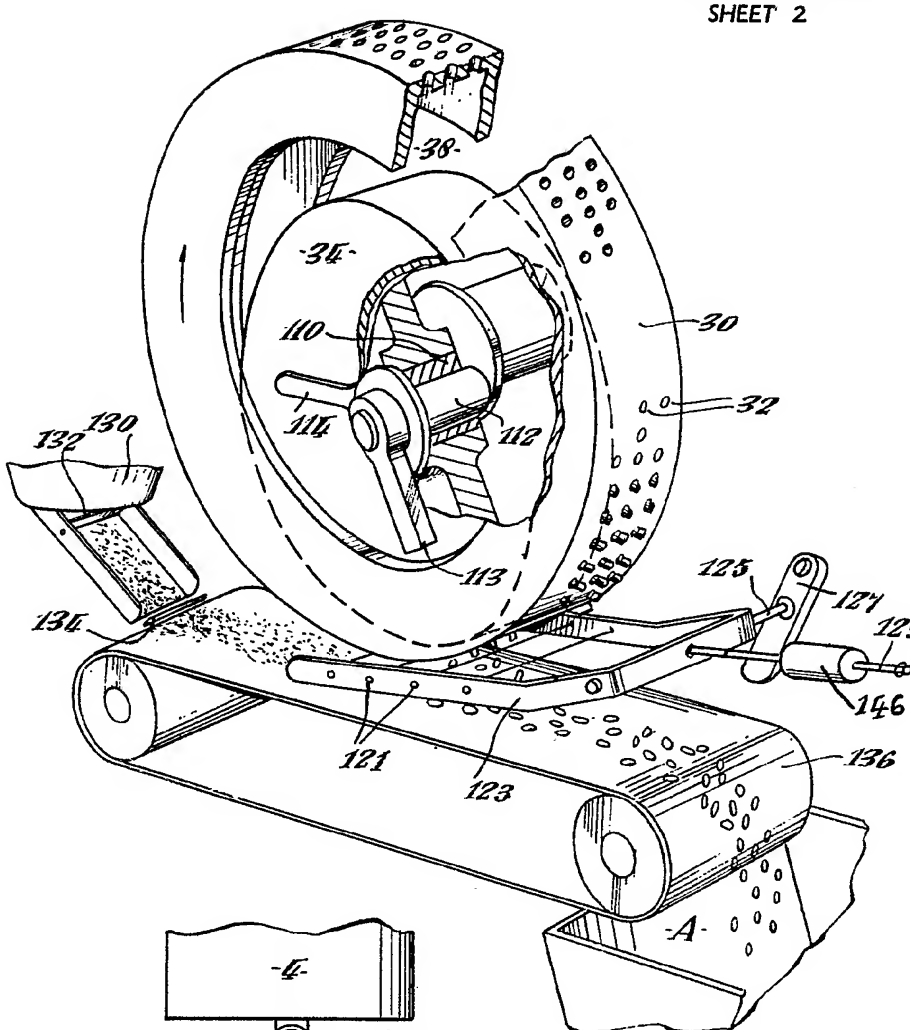
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Fig. 12.

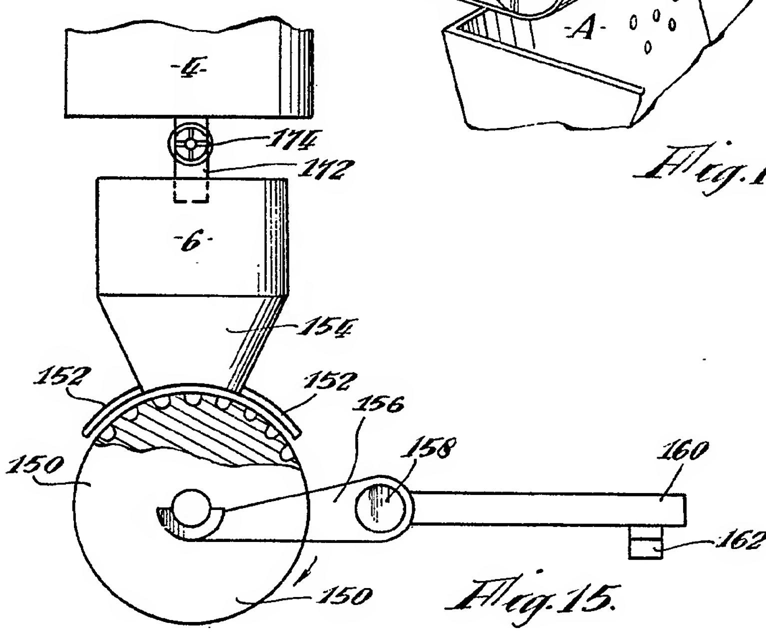
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Fig. 15.